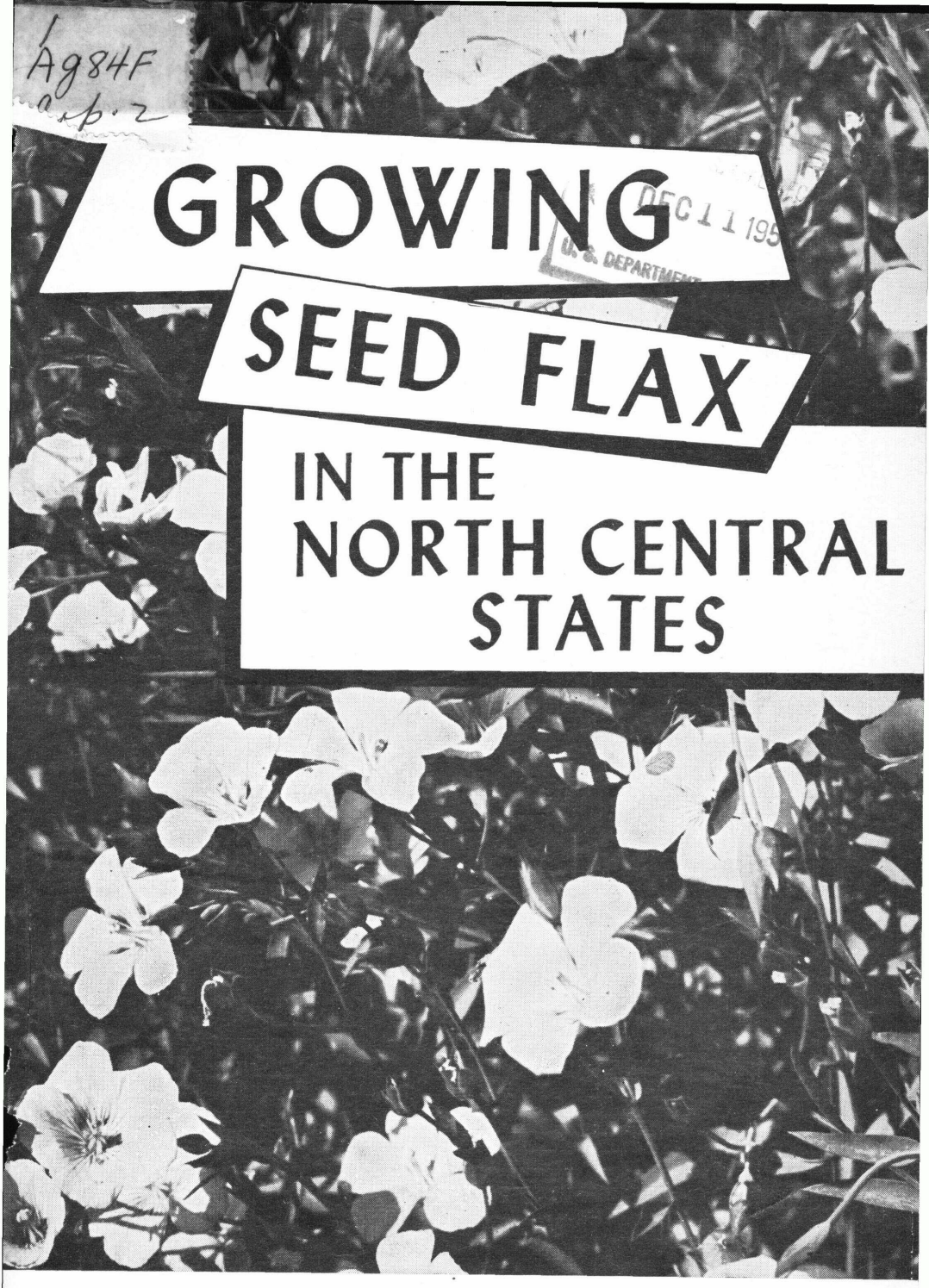
GROWING SEED FLAX IN THE NORTH CENTRAL STATES



Farmers' Bulletin No. 2122

UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

This publication is based on cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the North Dakota and Minnesota Agricultural Experiment Stations. It was prepared by J. O. Culbertson, agronomist, Crops Research Division, Agricultural Research Service; T. E. Stoa, agronomist, North Dakota Agricultural Experiment Station; R. S. Dunham, agronomist, Minnesota Agricultural Experiment Station; H. H. Flor, pathologist, Crops Research Division, Agricultural Research Service; J. J. Christensen, pathologist, Minnesota Agricultural Experiment Station; and R. E. Bothun, assistant agronomist, North Dakota Agricultural Experiment Station.

This bulletin supersedes Farmers' Bulletin 2036, Seed-Flax Production in the North Central States.

Washington, D. C. Issued November 1958

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 15 cents

GROWING SEED FLAX IN THE NORTH CENTRAL STATES

The flax plant[1] is the source of two valuable products—flaxseed (from which linseed oil is made) and fiber. Two distinct types of flax are grown—one for seed and the other for fiber. This bulletin discusses the growing of flax especially for seed.[2]

Flax is an annual plant that grows to a height of 12 to 40 inches. It has a distinct main stem and a short taproot. The slender root branches may extend to a depth of 3 to 4 feet in light soil. In thick sowing only the main stem develops, whereas in thin stands two or more branches may develop from the base of the plant. The flax flower has 5 petals and a 5-celled boll, or capsule, which contains 10 seeds when filled but not more than 10 except in abnormal double bolls.

Flax normally is self-pollinated but insects cause some crossing, and there is appreciable natural crossing in some varieties. Individual flowers open at sunrise on clear, warm days, and the petals usually fall before noon. The petals are blue, pale blue, white, or pale pink, depending on the variety. The seeds of most varieties are light brown, but in some varieties they are yellow, mottled, greenish yellow, or nearly black.

FLAX-GROWING AREAS

Flax for fiber was one of the first crops introduced from the Old World. Linseed oil was made in the United States as early as 1805.

Until about 1920 flax was a pioneer crop in American agriculture, the center of production always being near the frontier where new land was available. In 1850, Ohio and Kentucky were the leading flax-producing States. During the next 50 years the crop migrated with the advance of settlement from Ohio, across Indiana, Illinois, Iowa, and Minnesota, to North Dakota. This shift in areas of production was caused partly by the injurious effects of flax wilt in the older cultivated lands, but chiefly by the greater economy of production in the fertile virgin soils of the northern Middle West.

In recent years flax production has continued largely in western Minnesota, northeastern South Dakota, and all of North Dakota except the southwest. Flax is grown on smaller areas in Texas, Montana, California, and Arizona. Substantial acreages were grown in other areas during and immediately following World War II.

About 98 percent of the flaxseed acreage in the United States in 1955 was in Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, and

[1] *Linum usitatissimum* L.

[2] Information on the production of fiber flax, which is grown in the United States only to a limited extent, is given in U. S. Dept. Agr. Farmers' Bul. 1728, Flax-fiber Production. (Out of print, but may be consulted in libraries in most large cities.)

Montana (fig. 1). About 2 percent was in California, Texas, and Arizona, where most of the crop is sown in the fall or early winter.

The concentration of the acreage in the North Central States and Montana is largely because conditions in this area are favorable to flax growing. One factor is the large acreage of fertile land suitable for flax. Also, summer temperatures are moderate and rainfall is sufficient, but not excessive, to assure a good yield. Annual rainfall ranges from 30 inches in parts of Minnesota to 15 inches in eastern Montana. More important than total rainfall is the amount of precipitation that falls during the growing period. The warm-season rainfall ranges from 22 inches in Minnesota to 10 inches in Montana. Adequate moisture and relatively cool temperatures, particularly during the period from blooming to maturity, seem to favor both high oil content and high oil quality. In general, flax yields tend to decrease as precipitation diminishes. An excess of rain, however, may lead to lush growth, increased weed competition, and greater development and spread of destructive diseases.

For many years before World War II, flax production in the United States was insufficient to meet requirements of industry, and large quantities of flax were imported, chiefly from Argentina (fig. 2).

The Tariff Act of 1922 provided for a duty on imports of flaxseed and linseed oil. Although the rates have been changed to meet changing conditions, there has been a duty on both products continuously since that time. In 1957 the duty on flaxseed was 50 cents per bushel and on linseed oil, 4.5 cents per pound.

Since July 1, 1953, there has been an ad valorem fee of 50 percent in addition to the regular duty on all imports of flaxseed and linseed oil. This additional fee was imposed under section 22, Agricultural Adjustment Act of 1933, to prevent imports from materially interfering with or rendering ineffective the domestic price support program for flaxseed. Section 22 provides for changes in import restrictions when

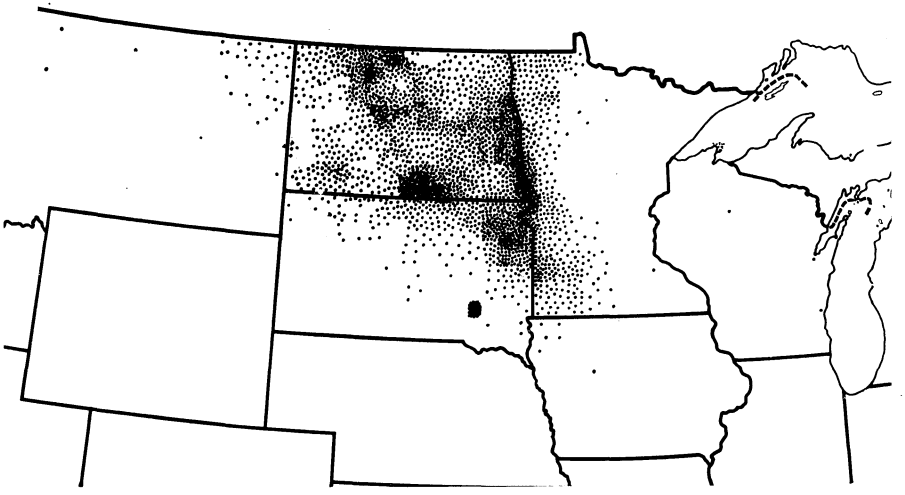


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Figure 1.—Distribution of flaxseed acreage in the North Central States, 1954. Each dot represents 2,000 acres. Estimated total area in U. S., 5,049,000 acres.

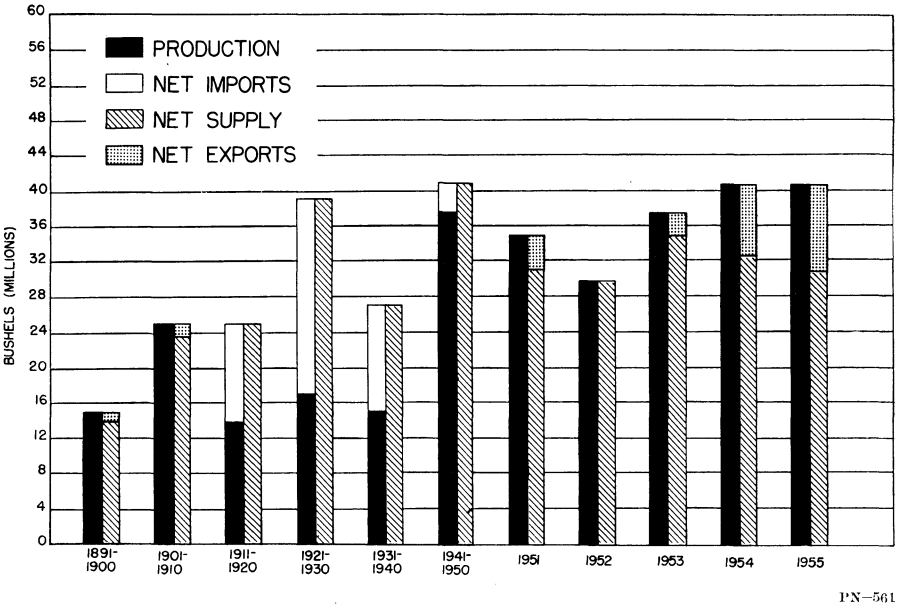


Figure 2.—Flaxseed production, net imports (including linseed oil in terms of seed), net exports, and net supply in the United States, 1891–1955.

warranted by changing conditions.

Prices of flaxseed have been supported since 1940. For 1947 and 1948 crops, the support price was set at the high level of $5.75 a bushel to encourage a further increase in domestic production because of difficulties in obtaining supplies from Argentina. Supplies in recent years have been adequate. The support price in 1957 was $2.92 a bushel—equivalent to 65 percent of the parity price.

USES AND MARKETS

Flaxseed yields from 32 to 44 percent of oil, based on dry weight. In commercial crushing about 19 pounds, or 2½ gallons, of oil is obtained from a bushel (56 pounds) of seed. Part of the oil (3 to 6 percent) remains in the cake. The yield of oil varies with the type or variety of flax and with the climatic conditions under which the crop is grown. In general, large-seeded varieties yield a higher percentage of oil than small-seeded varieties. On the other hand, the small-seeded varieties may produce oil of somewhat better drying quality.

If drought occurs when the seed is filling, that is, within 25 days after blossoming, the seed may be shrunken and the oil content will be low and of poor quality. High temperatures, which often accompany a period of drought, are especially injurious to flax because they reduce the yield and result in seed of lower oil content and lower oil quality.

Linseed oil has many uses in industry, some of the principal ones being in the manufacture of paint and varnish, linoleum, oilcloth, printer's ink, patent leather, and imitation leather, and as a core oil in making sand forms for metal casting.

In the manufacture of linseed oil, the solvent extraction method has almost entirely replaced older methods which depended on pressure to remove oil from the seed. In the solvent method, the seed is crushed

to free the oil, and a portion of the oil may be removed by pressing the crushed seed. Solvents are then used to remove most of the remaining oil.

After the oil is extracted from the seed, the remaining linseed cake is prepared for livestock feed either by grinding to linseed meal or by making pellets suitable for feeding in outdoor feed lots or on the range.

The principal markets for flaxseed are Minneapolis and Duluth, Minn. Most of the seed marketed in Minneapolis is processed there; that received at Duluth is shipped on Great Lakes steamers to eastern markets. Flaxseed produced in the Western States is crushed by mills located on the west coast. Other mills that crush some flaxseed are located in the areas where soybeans or cottonseed is produced. These mills usually crush more than one kind of oilseed.

Flax straw from seed-flax varieties is used in the manufacture of upholstery tow, insulating material, rugs, twine, and paper. Some of the better quality straw, produced in the more humid sections of the North Central States and under irrigation in California, is used in the manufacture of cigarette and other high-grade papers.

Flax straw, to be of value to processors, must be available in quantity and must be relatively free from weeds and from weather damage. Both environment and variety seem to influence the fiber characters of flax straw. Straw is shorter and of less desirable quality when grown under dry conditions than when grown with adequate effective rainfall. Rust, wilt, pasmo, and other diseases lower the quality of the fiber. Preliminary tests indicate that straw of different varieties differs in yield of fiber and efficiency of decortication.

The yield of straw varies chiefly with the amount of soil moisture available. In most areas the acre-yield approximates ½ to ¾ ton of marketable straw. Flax straw frequently is sold under contract with processing plants. Sometimes farmers bale the straw and deliver it at a specified point, or the processor may buy the straw in the stack or in the swath after combining. Because the value of the straw is low compared to the value of the seed produced, a variety should be selected for its ability to produce good yields of high-quality seed in the particular area.

VARIETIES

Nearly all varieties of seed flax now grown commercially in the United States belong to the wilt-resistant, short-fiber type. Other types include common (or "Russian"), Argentine, Indian, Abyssinian, and Golden (or yellow-seeded).

Many of the older varieties were developed by selection on the basis of wilt resistance and satisfactory seed yields. More recently, varieties resistant to both wilt and rust have been developed through hybridization. Varieties differ in time of maturity, disease resistance, plant type, flower and seed color, size of seed, capacity to yield, oil content, and oil quality. Each has some merit and is, therefore, better suited to some conditions than other varieties. Table 1 compares some of the important characters of the more widely grown varieties.

Most of the varieties are sufficiently wilt-resistant for farm production, provided a good crop rotation is followed. The varieties listed as having excellent rust resistance have been either immune or highly resistant in the North Central States. None of the varieties has satisfactory resistance to pasmo. Crystal and Marine seem to be the most tolerant; Viking (Golden) is the most susceptible.

TABLE 1.—*The leading flax varieties in the North Central States, some of their plant and seed characters, and their reaction to three important diseases (varieties listed in approximate order of maturity from early to late)*

Variety	Flower color	Seed color	Seed size	Relative maturity	Resistance to disease [1]		
					Wilt	Rust	Pasmo
Redwing	Blue	Brown	Small	Early	Fair	Fair−	Fair.
Sheyenne	do	do	Medium	do	Very good	Excellent	Do.
Raja	do	do	Large	do	Fair−	do	Do.
Marine	do	do	Medium	do	Good	do	Fair+.
Bolley	do	do	Medium+	do	do	do	Fair.
Dakota	do	do	Medium	Midearly	do	Poor [2]	Fair−.
Bison	do	do	Medium+	do	Very good	Poor	Fair.
Linda	do	do	Very large	do	do	Fair	Do.
Arrow	do	do	Medium	Midlate	do	Fair−	Do.
Rocket	do	do	Medium+	do	Fair	Excellent	Poor.
Viking (Golden)	Pink	Yellow	do	do	do	do	Very poor.
Victory	White	Brown	Large	do	Good−	Good [3]	Poor.
Norland	do	do	do	do	do	Good	Do.
Redwood	Blue	do	Medium+	do	Good	Excellent	Fair−.
Deoro	Pink	Yellow	do	Late	Fair	Good	Poor.
B5128	Blue	Brown	Large	do	Good−	Excellent	Fair.

[1] Reaction to the races now common in the North Central States. No flax variety has satisfactory resistance to pasmo.
[2] Immune to all common races until 1948.
[3] Victory is a mixture of lines, some of which are susceptible to races of rust now occurring in the North Central States.

GROWING THE CROP

CHOICE OF LAND

Flax should be grown only on clean land that seems likely to produce a good yield. Land foul with weed seeds, poorly drained, or subject to excessive drought should not be sown to flax.

In the corn-growing area of Minnesota and the Dakotas, land that will grow good corn usually is considered suitable for flax, provided it is not foul with weed seeds. To the north and west of the Corn Belt, flax usually is grown on the types of soil used for wheat or barley.

Special attention should be given to fitting flax into the cropping sequence. A rotation that includes (1) a small-grain crop; (2) a legume crop such as sweetclover, red clover, soybeans, or field peas; (3) corn or other intertilled crop; and (4) flax is very satisfactory. The most favorable rotation differs with individual farms, soil conditions, number of animals kept, need for feed and forage, and other factors that influence the kind and proportion of the crops to be grown.

Where intertilled crops are of major importance, a considerable acreage of flax is sown following them.

Flax usually yields satisfactorily when sown after small grain if the stubble has been plowed under in August.

Where moisture is ample, yields of flax following alfalfa or sweetclover frequently are good, but the abundance of soil nitrogen may stimulate weed growth to such an extent that harvesting is difficult. In the drier sections, alfalfa and sweetclover land often is low in moisture reserves, and flax may suffer from drought when it follows these crops.

Inclusion of a legume or a mixture of a legume and grass in the rotation or cropping system usually is beneficial to flax. It insures a soil high in available fertility and in root fiber and organic matter, which promotes better tilth. Such soil is less subject to crusting and has a larger capacity for absorbing and holding moisture.

Ordinarily flax does not do well on loose soil following potatoes or sugar beets, especially on old land that is likely to be foul with weed seeds. Digging these crops brings weed seeds to the surface where they germinate readily the following spring. It usually is better, therefore, to follow potatoes or beets with a crop that grows more vigorously than flax.

FERTILIZERS

Flax responds to fertile soil, and the best yields are obtained on fields where general fertility is high. Soils that produce high yields of small grains, corn, or soybeans usually are fertile enough to produce good yields of flax.

Use of commercial fertilizers is expanding rapidly in the North Central States, and some flax fields are fertilized. Experimental results obtained from fertilizer trials with flax have been conflicting. In some trials, considerable increases in yield have been obtained with the use of fertilizer; in other trials, little or no advantage can be shown.

Where commercial fertilizers have been found profitable for small grain, it is likely that they would be profitable for flax, also. In general, formulations found best for small grains prove best for flax. Since heavy applications of nitrogen stimulate weed growth, it usually is best to apply the nitrogen needed for flax to some other crop in the rotation.

PREPARATION OF SEEDBED

Regardless of the kind of soil or the previous cropping, the following objectives should be kept in mind in preparing the seedbed for

flax: (1) Control of weeds, (2) conservation of soil moisture, (3) proper disposal of stubble or trash, and (4) a firm seedbed.

Whether fall or spring plowing of small-grain stubble land is better for flax depends on the weather and soil conditions under which the flax is grown. In the humid areas and on the heavy soils of the Northern States, early fall plowing and early spring sowing generally are considered best. Plowing or disking stubble land in August stimulate the germination of weed seeds in the fall if moisture conditions are favorable. Later, freezing weather kills the weeds and dead plants, if large enough, hold the snow and prevent soil blowing.

In the drier sections of the Great Plains, fall rains may be too light to induce weed seeds to germinate. A winter cover of stubble or trash will catch and hold snow and thus conserve valuable moisture and help prevent soil erosion. Under these conditions, spring plowing frequently gives the best result, especially on lighter soils. In the Great Plains, spring-plowed land usually is freer from weeds than fall-plowed land. Working the seedbed with a harrow or packer immediately after spring plowing tends to conserve soil moisture. In drier sections, it is often the practice to plow, prepare the seedbed, and sow the flax in a single operation. This places the seed in moist soil so that germination is uniform and rapid, and the crop has a better chance to compete with early-starting weeds.

The depth of plowing or tilling the land may be an important factor in weed control. Plowing to the same depth as in a previous working may bring to the surface dormant weed seeds that had been turned under previously. Here they germinate and create a serious weed problem in the flax crop.

Pasture or sodland that is to be sown to flax in the spring preferably should be plowed the previous summer to allow the sod to settle and decay. Sodland broken in the spring after the grass has started growing should be packed with a heavy packer or with disks set nearly straight to make the surface firm. This should be done as soon as possible after breaking, so the seed may be sown before the turned sod dries. Plowing, harrowing or packing, and sowing often are done in one operation.

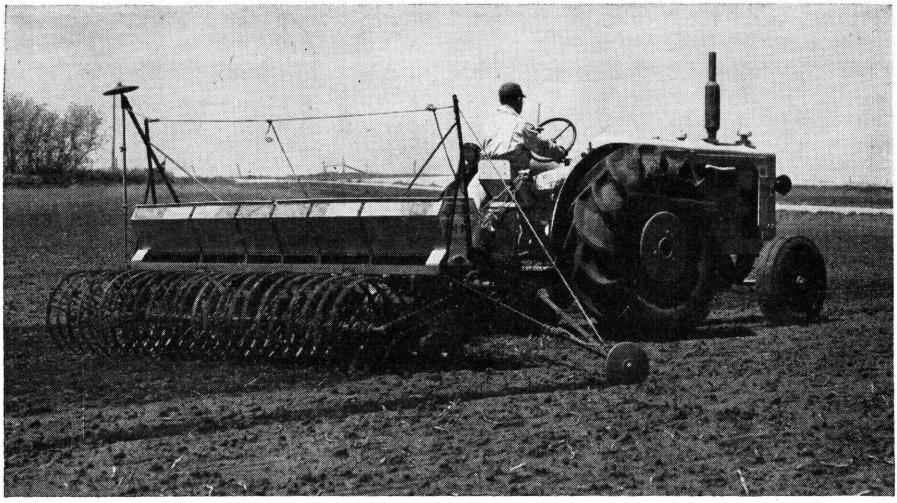
Land from which corn was harvested with a picker usually should be plowed before sowing flax. This buries the stalks so they do not interfere with seeding or harvesting. It is especially important to plow under the stalks where corn borers are prevalent. A heavy disking may be satisfactory where there are no corn borers, and a light disking of the stubble is sufficient where the cornstalks have been harvested for silage or fodder. Disked land should be harrowed before the flax is sown.

Flax germinates at a lower temperature than many of the grassy weeds that may become troublesome later. A well-prepared, firm seedbed will insure sowing at the proper depth. This, in turn, will result in prompt and uniform germination of the flax and the crop will get started before the weeds.

METHOD OF SOWING

Flax should be sown at a depth of 1 to 1½ inches with a grain drill rather than with a broadcast seeder. Drilling provides more uniform distribution and depth for the seed, which results in a more satisfactory stand.

A drill with press attachments (fig. 3) is most satisfactory because it will press the moist soil about the seed to insure prompt and even germination. If the drill does not have a press attachment, a soil packer may be attached behind the drill,



PN–562

Figure 3.—Sowing flax with a press drill on a firm seedbed.

or the field may be packed in a separate operation immediately following sowing.

If it is necessary to sow in loose soil, the pressure springs of the drill must be released and the weight of the disks depended on to place the seed at the proper depth.

TIME OF SOWING

Early spring sowing of flax generally produces the most satisfactory stands and the highest yields. In North Dakota and Minnesota, flax sown in late April or early May usually yields best. In general, flax should be sown at the time most suitable for sowing spring wheat or soon thereafter.

Flax sown early will make a large part of its growth in the cool weather of spring and early summer when soil moisture is likely to be more plentiful. Also, for best development, flax requires cool weather at the time of blooming and ample moisture and moderate temperatures until nearly ripe. Such conditions are more likely to prevail when flax is sown relatively early than when sown late.

Light frosts seldom injure flax in the seedling stage. Seedlings just emerging seem most tender, but even these will withstand a moderate frost, especially if the soil is moist and they are not injured further by drying winds. After the plants are 2 or 3 inches high and are hardened by exposure, they may endure temperatures as low as 18° for a short time without serious injury.

Flax in the green boll stage is susceptible to frost damage. The green seeds contain from 50 to 75 percent of moisture and may be killed by freezing temperatures that do not completely kill the leaves and stems.

The degree of injury from freezing varies with the minimum temperature, condition of the plants, the soil-moisture supply, and weather conditions both before and after freezing.

Deferred sowing may be necessary where early-starting weeds such as wild oats or Russian thistle are abundant. Early tillage helps to promote early germination of these weed seeds; subsequent tillage will destroy the young weed plants. Sometimes two or more crops of weeds can be destroyed in this manner, but sowing then must be de-

ferred until late May or early June.

On the other hand, when seeds of warm-weather weeds such as green or yellow foxtail (pigeon grass) are present, flax should be sown early so it will become established before these weeds get started. It usually is better not to sow flax on land foul with weed seeds.

When late sowing is unavoidable, sowing by the first week in June gives fair assurance that the crop will ripen before frost. Later sowing often results in low yields, even though the crop may escape frost (table 2).

Tests in Minnesota indicated that a delay of 10, 20, or 30 days after the first practical sowing date resulted in yield losses of 22, 23, and 47 percent, respectively. In North Dakota a similar test, using 10 varieties of flax, indicated that a delay in sowing of approximately 3, 5, and 7 weeks after the optimum sowing date (about May 1 at Fargo) resulted in an average yield loss of 5, 50, and 78 percent, respectively.

Flax varieties vary greatly in response to date of sowing. Early-maturing varieties, such as Sheyenne, Marine, and Bolley, mature in nearly the same length of time regardless of sowing date. However, late-maturing varieties, such as Deoro and B5128, require a progressively longer growing period with delayed sowing (table 2). Only early-maturing varieties are recommended for late and very late sowings.

RATE OF SOWING

The usual rate of sowing flax varieties with medium-sized seeds is about 2 pecks (28 pounds) an acre in Montana and the western Dakotas and 2½ to 3 pecks (35 to 42 pounds) in the eastern Dakotas and western Minnesota. In eastern Minnesota, where rainfall is

TABLE 2.—*Effect of date of sowing on average yield per acre of early-maturing, medium-maturing, and late-maturing varieties of flax, at Fargo, N. Dak., 1952–56, inclusive*

Variety	Average yield per acre when sown—				Average
	Early (Apr. 25–May 15)	Intermediate (May 16–31)	Late (June 1–20)	Very late (June 21–July 10)	
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Early-maturing:					
Bolley	19. 0	18. 8	14. 0	7. 7	14. 9
Marine	18. 2	17. 6	12. 9	6. 2	13. 7
Sheyenne	16. 6	17. 1	11. 3	6. 3	12. 8
Medium-maturing:					
Rocket	19. 7	17. 6	10. 5	3. 4	12. 8
Redwood	19. 5	18. 7	6. 0	2. 0	11. 6
Victory	16. 9	17. 2	5. 8	2. 1	10. 5
Dakota	15. 4	13. 8	6. 9	2. 5	9. 6
Linda [1]	18. 1	18. 4	6. 4	1. 9	--------
Late-maturing:					
Deoro [1]	19. 5	15. 6	4. 2	. 4	--------
B5128	19. 6	16. 5	4. 7	1. 1	10. 5
Average (10 varieties)	18. 1	17. 2	9. 0	3. 9	12. 0

[1] Data for 1954–56 only.

heavier, a rate of 3 pecks (42 pounds) or even 1 bushel (56 pounds) to the acre is considered advantageous. These rates may be slightly reduced for a small-seeded variety and increased for a larger-seeded type. (See table 1.)

As a general rule, sowing at the heavier rate insures a thicker stand and may help control weeds. However, less seed is required for a satisfactory stand on seedbeds where conditions are favorable for prompt and even germination than on seedbeds where conditions are less favorable.

More uniform stands of flax frequently are obtained if the seed is treated with a suitable seed disinfectant to control seedborne diseases.

TREATING SEED

Treating seed with chemical fungicides such as Ceresan M, Captan, and Panogen,[3] at the rate of 1 to 1½ ounces per bushel of seed, protects against damage from disease. Treatment is effective mostly against pathogens that are carried from one year to the next on the seed but also protects the germinating seed to some extent against injury from soilborne organisms that cause damping-off and seedling blight. Fungicides are marketed either as dusts or liquids and can be purchased in drug stores, seed houses, and other places dealing in seeds and similar products.

Clean dry seed may be treated several weeks in advance of sowing without injury to the germination of the seed. The beneficial effect of treatment is increased if the seed is treated at least 24 hours before sowing.

[3] Other good fungicides are on the market. Mention of these products does not imply that the U. S. Department of Agriculture endorses them over other similar products not named.

CAUTION: Chemical fungicides usually contain mercury and are poisonous. They should be handled and stored with care. Read and follow exactly the directions for use supplied by the manufacturer.

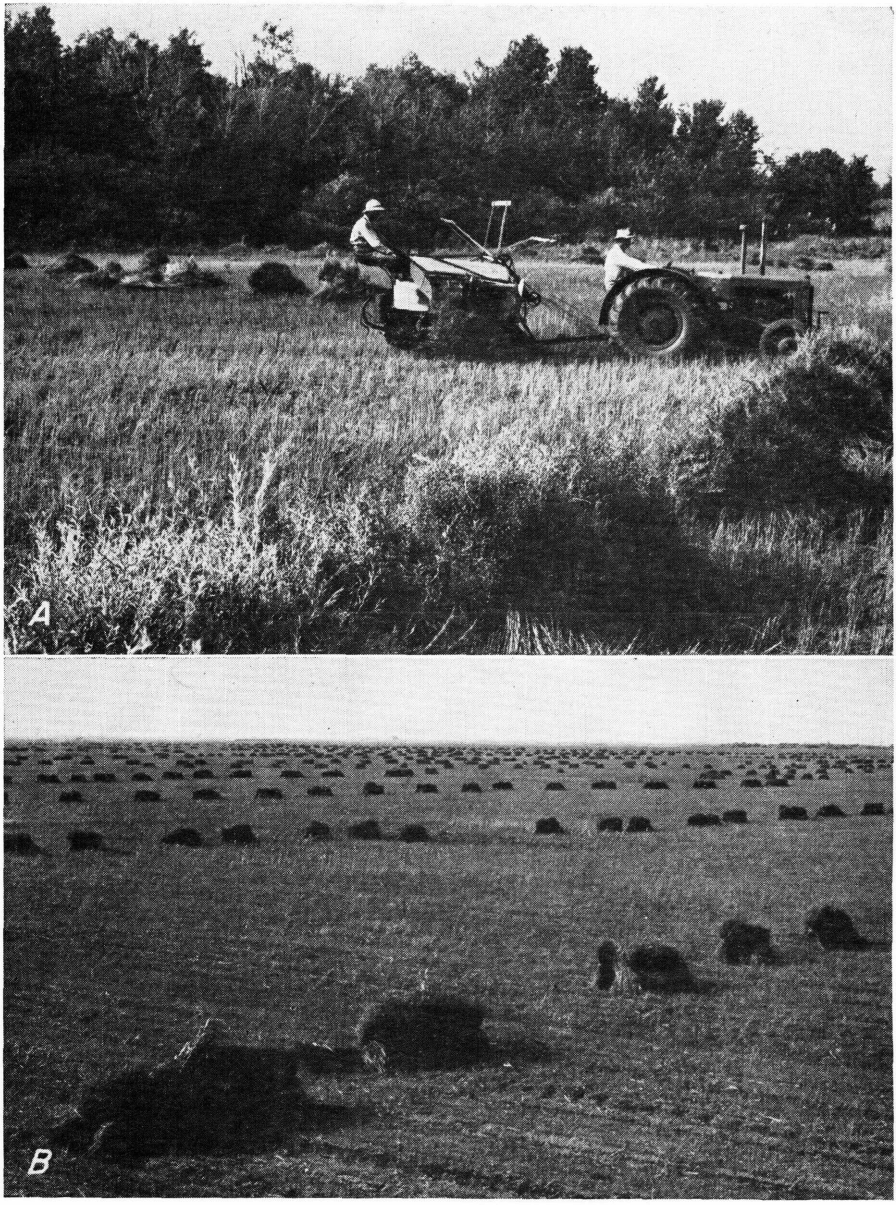
HARVESTING

Maturity in flax is judged by the color of the bolls rather than by the color of the straw. The crop is ripe enough to harvest when 90 percent of the bolls have turned brown. Any delay after this stage increases the chance of storm damage and allows weeds to grow and become more troublesome. Flax may continue to bloom until frost if sown late or if the season is wet and cool. The seeds from these late flowers seldom mature and are lost during threshing and cleaning.

Flax may be harvested with a grain binder (fig. 4, *A*), with a swather (windrower) (fig. 5), or by direct combining. When flax cut with a binder is shocked, the bolls are kept from the damp ground and the seed usually is not damaged. Small or long, narrow shocks should be built to allow good ventilation (fig. 4, *B*).

The combine or the windrower (swather) often can be used to harvest flax that is too short to cut with a grain binder. This advantage in the use of the combine, however, does not justify the growing of short-strawed varieties, which are more difficult to harvest by any method.

The cost of harvesting is materially less when the combine is used. Direct combining is the cheapest method and is entirely satisfactory when the flax is thoroughly dry and free of weeds. However, direct combining is less common than use of the swather and pickup combine, because few fields are free of weeds



PN–563

Figure 4.—*A*, Harvesting seed flax with a grain binder; *B*, narrow shocks that permit rapid drying.

and few ripen uniformly. The crop in the swath is in condition to thresh after a few days of dry weather (fig. 5).

In late fields in Montana and North Dakota, harvesting sometimes is delayed until frost has killed the weeds. Weeds dry rapidly after being frozen, and the flax can be harvested with a combine within a few days. Ordinarily, flax will stand for some time after ripening without loss from shattering, but it may shatter somewhat

PN–564

Figure 5.—Swathing flax. A combine with a pickup attachment will be used to thresh the crop after it has dried for a few days.

in very dry, hot weather. Delaying harvest until after frost can be recommended only for late flax that will not be standing long after it is ripe.

The seedcoat of flax is injured easily during threshing, especially if the seed is unusually dry. It is advisable to use no more teeth in the concaves than necessary to recover all the seed, and the speed of the cylinder may be reduced slightly if the flax is very dry.

Most combines have special "rub-bar" types of cylinders that greatly lessen seed injury. Mechanical injury to the seed reduces the germination. It is important that great care be given to threshing flax, and particularly if the seed is to be used for sowing the next crop.

CLEANING AND STORING THE SEED

Hundreds of cars of flaxseed shipped to market contain from 10 to 40 percent of dockage, consisting of cracked flaxseed, other grains, weed seeds, and chaff. Except for the cracked flaxseed and the weed seeds that contain considerable oil, these admixtures are mostly undesirable when extracting linseed oil, but they are of value for feed.

Excessive dockage may be screened from the flax before marketing to save freight charges, if the screenings are of sufficient local value to offset the cleaning costs and the losses from shrinkage during cleaning. However, not many farms and not all local elevators are equipped for such cleaning. Although the screenings are thus saved for feeding in the community, they often are more valuable in the terminal markets where they can be incorporated into commercial mixed feed. Dockage containing weed seeds to be used for feed should be finely ground, so that viable weed seeds will not go into farm manure to be scattered about the farm.

In cleaning flax for seed, a steel-wire sieve with meshes 4 by 16 an inch (or 4 by 14 for large-seeded varieties) will separate the grain and the larger weed seeds from flax. A metal sieve with round holes one-fourteenth of an inch in diameter will remove most of the small weed seeds and fragments of flaxseed. The air blast can be regulated to blow out all immature and shrunken flaxseed and trash.

Flax intended for seed should be recleaned, and only dry, sound, plump seeds should be saved. This will reduce the spread of wilt, rust, and other diseases that may be carried as spores on broken stems, chaff, and immature seeds.

Flaxseed for storage should be dry and should be stored only in a dry place. Air-dry flaxseed contains only 6 to 8 percent of moisture.

WEED CONTROL IN FLAX

CULTURAL PRACTICES

Weeds are a serious handicap in the production of flax. The characteristic short growth and small leaves that make flax an especially good companion crop for grass seedlings are responsible for its poor competition with weeds. Practical control of weeds involves careful selection of the field to be sown and good cultural and chemical practices.

The field chosen for flax can be made relatively free from annual weeds by controlling weed seed production the preceding year.

When flax is to follow grain, plowing the stubble soon after harvest keeps many weeds from producing seed. Working the land after plowing will cause many weed seeds in the surface soil to germinate, if moisture is adequate, but the seedlings that grow will be killed by freezing weather later. If the soil is stirred to a depth of not more than 3 or 4 inches when preparing the seedbed for flax the following spring, fewer weed seeds will germinate and grow.

It is possible also to provide a clean surface layer of soil in corn or soybean fields in preparation for flax the following spring. The early after-harvest tillage just described should be practiced in the fall before planting the row crop in the spring. Planting of corn and soybeans should be delayed as long as practicable the next spring to permit germination of as many weeds as possible. These weeds should be killed in preparing the seedbed. When weather conditions permit, harrowing or cultivating with a rotary hoe is effective in killing weeds that germinate late. The crop should be well rooted (corn, 4 to 6 inches tall; soybeans, 3 to 7 inches tall) and the weeds should be small seedlings when the harrow or rotary hoe is used.

Delayed sowing of flax to permit spring tillage for control of wild oats is successful in some areas, although the delay is sometimes detrimental to the flax. For delayed sowing, only early-maturing varieties, such as Marine, should be used.

Tests in Minnesota have shown that flax yields equally as well following oats when the field is plowed immediately after harvest and rough-worked as following corn that had been kept clean. Grassy weeds other than wild oats are controlled equally well by either method. Wild oats can be controlled best when fallow or corn ground is kept very clean the year preceding the flax, and somewhat less effectively when alfalfa or Sudan grass precede the flax. Post-harvest cultivation of oat-stubble land is unsatisfactory for the control of wild oats. An underseeding of alfalfa in oats has likewise failed to control them and even winter wheat following a summer fallow has been ineffective.

Perennial weeds are difficult to control in flax. It is better to select a field relatively free from perennial weeds than to try to control them in the flax crop by post-emergence applications of herbicides. In humid areas, however, it is possible to kill quackgrass with applications of TCA or dalapon in the fall and sow flax the next spring. In subhumid regions or in years of dry falls and dry springs, the residual effects from fall applications may extend into the next growing season.

Although flax is relatively tolerant to TCA and dalapon and generally is not affected by these residues, injury may result if there is little rain in fall and spring. In the flax area of the North Central States, TCA, applied at the rate of 20 to 25 pounds per acre to plowed ground in the late summer or early fall, will kill quackgrass.

Dalapon is effective when applied to quackgrass that has a good growth of foliage from 4 to 10 inches tall. Fall treatments of 10 to 12 pounds per acre, followed in a week or two by plowing or other soil preparation, will control quackgrass the following year.

With whatever method is used to create a surface layer relatively free from weed seeds, the clean land should not be plowed after harvesting the corn or soybeans. If it is, the clean surface layer will be turned under and a new crop of weed seeds may be brought to the surface. The seedbed for flax should be prepared by shallow tillage.

CHEMICAL PRACTICES

Some chemical methods can be used to control annual weeds in crops that precede flax. The effectiveness of these herbicides, however, depends on factors that vary from region to region. Furthermore, new herbicides are introduced at frequent intervals. Specific recommendations for chemical weed control in crops preceding flax should be obtained from your local experiment station, extension service, or other qualified source.

DISEASES OF FLAX

Losses from diseases are largely responsible for the concept that flax is a risky crop and "hard on the land." This idea developed when wilt-susceptible varieties were being grown. Although losses from disease are sometimes spectacular, in most recent years disease losses have been smaller in flax than in competing cereal crops.

Wilt, rust, and pasmo are the most important flax diseases in the United States. Anthracnose, stem break (browning), damping-off, seedling blight, heat canker, aster yellows, curly top, and boll blight are widely distributed and occasionally destructive.

Both the prevalence and the destructiveness of a disease vary from one season to another, depending on environmental conditions, prevalence of particular races of the disease organism, and varieties grown. In some years natural and mechanical injuries to flaxseed are responsible for poor stands.

WILT

Wilt may attack the flax plant in all stages of development. The roots of seedlings may be completely rotted and the plants "damped-off."

When older plants are attacked, they remain upright but may wilt rapidly and die or may be stunted. The lower leaves may turn yellow and fall off. The main stem may be killed and new, apparently healthy branches will develop from the base. Sometimes only a part of the stem is affected, that is, a dead-brown infected streak may extend up one side in sharp contrast

with adjacent green tissue. Often premature ripening is the only indication of a weak infection or a late attack.

Although flax wilt is spread from one section to another on infected seed or flax refuse, the fungus is so prevalent in the soils of the flax-growing area of the North Central States that only wilt-resistant varieties can be grown successfully. Some varieties are highly wilt-resistant; others are only moderately so (table 1 and fig. 6).

RUST

Flax rust thrives best on young, vigorously growing plants. Cool, moist weather favors rust development; hot, dry weather checks it.

Rust first appears as bright-orange pustules on the leaves and stems of the plants. Each pustule produces numerous spores that are readily carried by the wind to other flax plants, thus spreading the disease. When weather conditions are favorable, a new crop of spores may be produced about every 10 days. Late in the season the orange pustules, especially those on the stem, enlarge and become dark brown to black. This is due to the formation of the thick-walled overwintering spores. In spring these resting spores germinate and infect the young flax plants.

In the North Central States, rust overwinters on the old flax straw and stubble of previous years. For this reason, flax should not be sown on the same land 2 years in succession, or near fields of unplowed flax stubble. Good fall plowing that buries the straw and stubble aids in controlling the disease, but the most effective control for rust is the use of resistant varieties. Sheyenne, Raja, Marine, Bolley, Linda, Rocket, Viking, Norland, Redwood, Deoro, and B5128 have been highly rust-resistant. (See table 1.)

PASMO

Pasmo is primarily a disease of the maturing tissues of the flax plant. It first appears as yellow-brown circular lesions on the cotyledons (seed leaves) of young plants. Later the yellow-brown spots appear on older leaves at the lower parts of the stems. The stems are fairly resistant when young and growing vigorously, but they become more susceptible when the plants begin to form bolls. Stem

PN–566

Figure 6.—In experiments at the North Dakota Agricultural College, Fargo, plot 30 has been cropped continuously to flax since 1890. Only highly wilt-resistant strains can survive on it.

lesions may enlarge rapidly, especially on certain varieties, and extend both up and down the stem and around it. In early stages of stem infection occurrence of irregular bands of brown alternating with the uninfected green parts of the stem is a striking characteristic. The brown lesions run together as the plants ripen prematurely, and lesions may become much darkened by other disease organisms. Usually the plants are not heavily infected until they are nearing maturity. The amount of damage is not readily determined but it may induce seed and boll blight, damage the fiber, and reduce yields materially.

Pasmo overwinters on infected straw and stubble. Therefore, proper crop rotation and plowing under the flax residues aid in controlling the disease. Although no variety is classified as resistant, many of them are so tolerant that they are not damaged greatly unless conditions are exceptionally favorable for the development of the disease (table 1).

ANTHRACNOSE

All parts of the flax plant are attacked by anthracnose. In the North Central States it occurs chiefly as a seedling blight, reducing stands. It is a seedborne disease that often kills the seedling before it breaks through the soil or shortly after it emerges. Infected seedlings commonly have water-soaked lesions on the cotyledons. The spores are washed down the stems during rainy periods and form sunken brownish cankers on the seedlings at the soil line. Infected seedlings may break over at the canker and die.

As anthracnose is a seedborne disease, the use of disease-free seed is the most effective control. Treatment of seed with a suitable chemical disinfectant, as described on page 10, is effective in reducing the damage.

STEM BREAK (BROWNING)

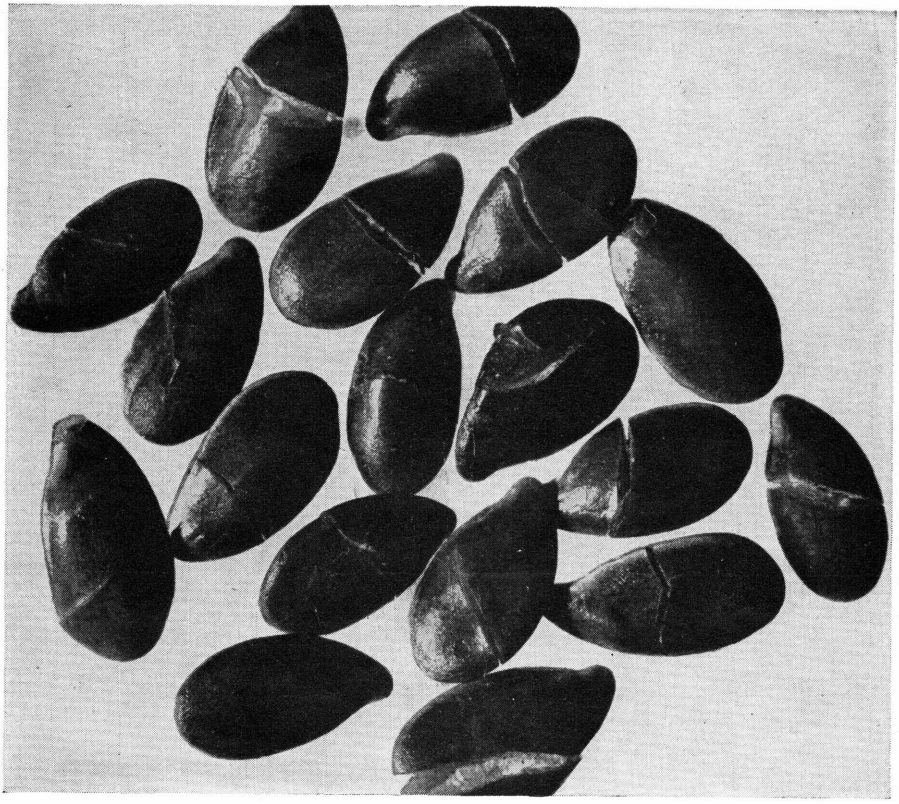
Stem break (browning), a seedborne disease, is of little economic importance in the United States. It is primarily a disease of seedlings and adult plants. Round, gray-to-brown lesions appear first on the cotyledons. These lesions often enlarge and the infection spreads to the stem where they produce a canker, usually on the basal portion of the stem. The stem becomes brittle and is weakened at the cankered region and may break over, hence the name stem break. Often the broken stem is not completely severed and the plants may partly recover, but they will not produce the normal amount of seed. The brown spots on the leaves and stems of older plants resemble those of pasmo but are smaller, and those on the stems usually are most prominent at a leaf scar.

Varieties of flax differ in their reaction to this disease. Use of clean seed, treated as recommended on page 10, is the most effective control measure.

DAMPING-OFF AND SEEDLING BLIGHT

Seedling blight of flax is caused by a number of micro-organisms that are carried on the seed or are present in the soil. The fungi may rot the underground parts of the plant or kill the seedlings before they emerge; also rotting of the seed before germination is common.

At least three types of seed injury are associated with poor field stands. The most common injury is the cracking, splitting, and chipping of the seedcoat and even of the embryo itself during threshing (fig. 7). Another defect is a split at the small end of the seed, which in some years is common in yellow-seeded varieties but of little importance in brown-seeded ones. The



PN–567

Figure 7.—Mechanical injury to flaxseed (magnified 6 times).

seedcoat curls back at this point to make an opening somewhat like that of a fish's mouth. Often the opening and cracks are so small they cannot be seen without the aid of a good magnifying glass, but they are big enough for fungi to enter. The third type of injury results from weathering in the field.

Injurious fungi may grow on or into the seed in wet weather when the bolls are forming and also after they are ripe. They may kill the seed or weaken it so the seedlings are more susceptible to attack. Treatment of injured seed with a suitable chemical disinfectant, as described on page 10, may increase the stand greatly and help prevent damping-off and seedling blight (fig. 8).

ASTER YELLOWS AND CURLY TOP

Aster yellows and curly top are two virus diseases of flax. Aster yellows is prevalent in the major flax-growing region of the United States, extending into Canada, whereas curly top is more prevalent on the Pacific Coast and in Texas.

Aster yellows in flax (fig. 9) is characterized by a yellow stunted growth, contorted foliage, distortion and proliferation of the floral parts of the plant, development of prominent yellow, star-shaped calyxes, and failure of boll formation. Usually the entire plant is involved, but sometimes only a portion of the plant appears to be infected. The virus is spread by the six-spotted leafhopper.

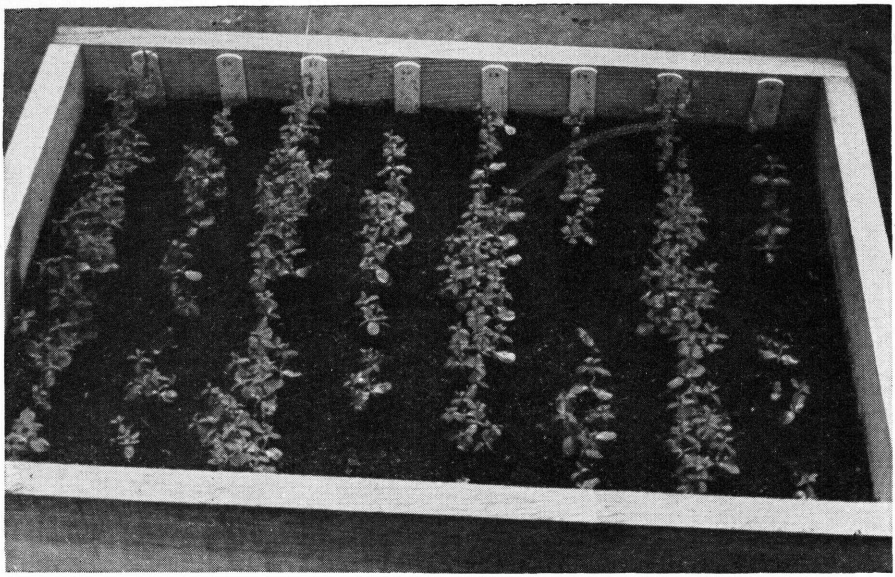


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Figure 8.—Effect of chemical treatment of injured seed of flax. Four varieties, 2 rows of each variety (treated and untreated) with 100 seeds planted in each row.

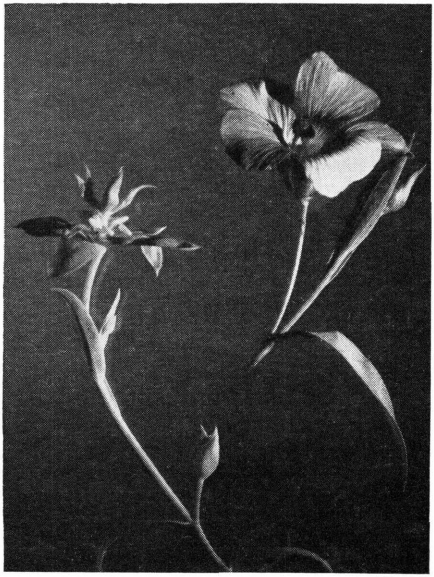

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Figure 9.—*Left*, yellowing and malformation of flax flowers caused by aster yellows. *Right*, normal flower.

Curly top in seedlings is characterized by irregular-shaped, wavy, yellow leaves, and marked shortening of the internodal region. Older plants are generally somewhat twisted and the blooming period is greatly reduced. The flowers that form are smaller than normal and the floral parts usually are compressed. This virus is spread by the beet leafhopper.

As yet there are no practical control measures for the prevention of these diseases.

BOLL BLIGHT

Boll blight is one of the most common diseases of flax in the Upper Mississippi Valley. It usually is characterized by prominent lesions on the exterior of the boll. Usually the boll contains one or more dark, discolored, shriveled, or abnormal seeds and sometimes no seeds develop (fig. 10).

Boll blight may be caused directly by the organism attacking the boll or indirectly by injuries to the plant by such diseases as pasmo, root rot, and wilt. The organism associated with infected bolls and seed varies greatly with location

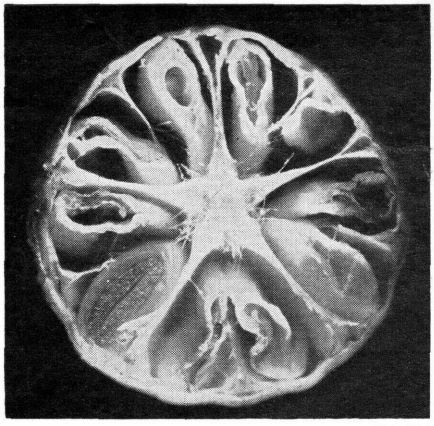

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Figure 10.—Ripening flax boll showing 9 defective seeds and 1 normal seed.

and the year in which the flax is grown. Mechanical injuries, such as those induced by hail and insects, tend to increase the percentage of infection.

HEAT CANKER

Heat canker, a nonparasitic disease, often greatly reduces stands of flax, especially in semiarid regions. The high temperatures of the surface soil injure the plant tissues in contact with it. Thin stands and formation of a surface-soil crust are conducive to heat canker. If the plants are injured when small, the stems become sharply constricted at the ground line, the tissues collapse, and the plants fall over and die. When the plants are larger, the outer tissues are injured and the plants respond by producing additional cork tissue as an overgrowth to the injury. This wound tissue is brittle, and the plant may break off at the soil line during later stages of growth if exposed to strong winds. Early sowing and sowing of sufficient seed to obtain stands thick enough to shade the ground are the most effective control measures for heat canker.

SUMMARY OF DISEASE CONTROL

Flax diseases may be controlled or reduced by the following:

1. Growing resistant and recommended varieties.
2. Selecting sound and disease-free seed.
3. Treating seed with a suitable fungicide.
4. Sowing early and following other good cultural practices.
5. Field sanitation and a good cropping sequence.

COMMON AND SCIENTIFIC NAMES OF WEEDS IN FLAX

COMMON NAME	SCIENTIFIC NAME
Wild oats	*Avena fatua*
Wild buckwheat	*Polygonum convolvulus*
Smartweed	*Polygonum pennsylvanicum* and *P. persicaria*
Wild mustard	*Brassica kaber*
Lambsquarters	*Chenopodium album*
Ragweed	*Ambrosia artemisiifolia*
Rough pigweed	*Amaranthus retroflexus*
Foxtail	*Setaria viridis; S. glauca; S. faberii*
Barnyard grass	*Echinochloa crusgalli*
Fanweed (Frenchweed or stinkweed)	*Thlaspi arvense*
Cocklebur	*Xanthium pennsylvanicum*
Marsh elder	*Iva xanthifolia*
Canada thistle	*Cirsium arvense*
Sow thistle	*Sonchus arvensis*
Russian pigweed	*Axyris amaranthoides*

CAUSAL ORGANISMS OF FLAX DISEASES

Disease	Causal organism
Wilt	*Fusarium lini*
Rust	*Melampsora lini*
Pasmo	*Septoria linicolum*
Anthracnose	*Colletotrichum lini*
Stem break	*Polyspora lini*
Seedling blight	*Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp., and *Colletotrichum lini*
Aster yellows	Virus transmitted by six-spotted leafhopper (*Macrosteles fascifrons*)
Curly top	Virus transmitted by beet leafhopper (*Circulifer tenellus*)
Boll blight	*Alternaria* spp., *Colletotrichum linicolum*, *Septoria linicolum*, *Fusarium* spp.

U. S. GOVERNMENT PRINTING OFFICE: 1958

CHECK up on these accident hazards around your farm . . .

√ Is farmyard clear of tools, broken glass, loose strands of barbed wire, nail-studded boards?

√ Are water tanks, cisterns, and wells protected?

√ Are ladders and steps in good repair?

√ Are pitchforks, rakes, shovels, and other sharp tools kept in racks?

√ Are electric circuits and appliances in good condition?

√ Is unused lumber carefully stacked?

√ Are buildings and fences in good repair?

clean up your farm

to make it attractive and SAFE